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Treatment Manual

Chemical Treatments

Fumigants • Methyl Bromide • Tarpaulin Fumigation

Contents

Methods and Procedures	page-2-4-2
Materials Needed	page-2-4-2
PPQ Officer Provides	page-2-4-2
Fumigator Provides	page-2-4-2
Preparing to Fumigate	page-2-4-3
Step 1—Selecting a Treatment Schedule	page-2-4-3
Step 2—Issuing a PPQ Form 523 (Emergency Action Notification)	page-2-4-4
Step 3—Determining Section 18 Exemptions and Sampling Requirements	page-2-4-4
Step 4—Selecting a Fumigation Site	page-2-4-4
Step 5—Arranging the Stack	page-2-4-7
Step 6—Arranging and Operating Fans	page-2-4-10
Step 7—Placing the Gas Introduction Lines	page-2-4-11
Step 8—Placing the Gas Sampling Tubes	page-2-4-11
Step 9—Padding Corners	page-2-4-13
Step 10—Measuring the Temperatures	page-2-4-14
Step 11—Covering the Stack	page-2-4-16
Step 12—Sealing the Tarpaulin	page-2-4-16
Step 13—Measuring the Volume	page-2-4-17
Step 14—Calculating the Dosage	page-2-4-17
Step 15—Making a Final Check	page-2-4-18
Conducting the Fumigation	page-2-4-19
Step 1—Introducing the Gas	page-2-4-19
Step 2—Testing for Leaks	page-2-4-20
Step 3—Taking Concentration Readings	page-2-4-21
Step 4—Determining the Need to Add Gas and Adjust Exposure	page-2-4-23
Special Procedures for Adding Gas and Extending Exposure Period	page-2-4-23
Special Procedures for Fruits, Vegetables, or Perishable Commodities Using Schedule T101-a-1 or Equivalent	page-2-4-25
Special Procedures for Adding Gas to Oak Logs and Lumber Using T312 or Equivalent	page-2-4-28
Step 5—Exhausting the Gas	page-2-4-29
Aerating the Enclosure	page-2-4-29
Responsibility for Aerating the Commodity	page-2-4-29
Materials Needed	page-2-4-30
Securing the Area	page-2-4-30
Wearing Respiratory Protection	page-2-4-31
Aerating Nonsorptive, Containerized Cargo—Indoors and Outdoors	page-2-4-32
Step 1—Installing Exhaust System	page-2-4-32
Step 2—Aerating the Commodity	page-2-4-32
Aerating Nonsorptive, Noncontainerized Cargo—Indoors and Outdoors	page-2-4-33
Step 1—Installing the Exhaust System	page-2-4-33
Step 2—Aerating the Commodity	page-2-4-33

Aeration Procedures for Fresh Fruits, Vegetables, and Cut Flowers—Indoors or Outdoors [page-2-4-35](#)

Step 1—Installing Exhaust System [page-2-4-35](#)

Step 2—Aerating the Commodity [page-2-4-35](#)

Aerating Sorptive, Noncontainerized Cargo—Indoors and Outdoors [page-2-4-36](#)

Step 1—Installing the Exhaust System [page-2-4-36](#)

Step 2—Aerating the Commodity [page-2-4-37](#)

Aerating Sorptive Commodities in Containers—Indoors and Outdoors [page-2-4-38](#)

Step 1—Installing the Exhaust System [page-2-4-38](#)

Step 2—Aerating the Commodity [page-2-4-38](#)

Methods and Procedures

The procedures covered in this section provide PPQ Officers and commercial fumigators with the methods, responsibilities, and precautions for tarpaulin fumigation.

Materials Needed

PPQ Officer Provides

- ◆ Calculator (optional)
- ◆ Colorimetric tubes (Draeger/Kitagawa)
- ◆ Desiccant (Drierite[®])
- ◆ Forms (PPQ Form 429 and APHIS Form 2061 if necessary)
- ◆ Halide leak detector
- ◆ Self-contained breathing apparatus (SCBA) or supplied air respirator to be used by PPQ officer
- ◆ Tape measure (as back-up for fumigator)
- ◆ Thermal conductivity unit^{1, 2}
- ◆ Thermometer (as back-up for fumigator)

Fumigator Provides

- ◆ Auxiliary pump for purging long gas sample tubes
- ◆ Carbon dioxide filter (Ascarite[®])
- ◆ Colorimetric tubes (Draeger/Kitagawa)
- ◆ Desiccant (Drierite[®], anhydrous calcium sulfate)

¹ If fumigating oak logs or lumber for export, the unit must be capable of reading 400 oz.

² T/C unit must be calibrated annually by the Oxford Plant Protection Laboratory. If requested, the Oxford Plant Protection Laboratory will calibrate a commercial fumigator's T/C unit.

- ◆ Electrical wiring (grounded, permanent type), three prong extension cords
- ◆ Exhaust blower and ducts
- ◆ Fans (circulation, exhaust, and introduction)
- ◆ Framework and supports
- ◆ Gas introduction line
- ◆ Gas sampling tubes (leads)
- ◆ Heat supply
- ◆ Insecticides and spray equipment
- ◆ Loose sand
- ◆ Measuring Tape
- ◆ Methyl bromide
- ◆ Padding
- ◆ Sand or water snakes or adhesive sealer
- ◆ Scales or dispensers
- ◆ Self-contained breathing apparatus (SCBA) or supplied air respirator
- ◆ Tape
- ◆ Tarpaulin and supports (See [page-2-4-13](#) for specifications)
- ◆ Thermal conductivity unit^{3, 4}
- ◆ Thermometer
- ◆ Volatilizer
- ◆ Warning signs
- ◆ Tape measure
- ◆ Thermometer

Preparing to Fumigate

Step 1—Selecting a Treatment Schedule

Select a treatment schedule to effectively eliminate the plant pest without damaging the commodity being fumigated.

³ If fumigating oak logs or lumber for export, the unit must be capable of reading 400 oz.

⁴ T/C unit must be calibrated by the Oxford Plant Protection Laboratory. If requested, the Oxford Plant Protection Laboratory will calibrate a commercial fumigator's T/C unit.

Turn to the Treatment Schedule Index and look up the available treatment schedule(s) by commodity (example—apples, pears, or citrus) or by pest (example—Mediterranean fruit fly). Some commodities may have several treatment schedules. The “Fumigants—Methyl Bromide” section on Residual Effects lists those commodities which may be damaged by MB. Each treatment schedule lists the target pest or pest group (e.g., *Ceratitis capitata*, surface feeders, wood borers...), commodity, or both pest and commodity. If there is no schedule, contact the Oxford Plant Protection Laboratory to see if a schedule is available under a FIFRA Section 18 Exemption. If a treatment is required, go to **Table 2-4-1**.

TABLE 2-4-1: Determine Reporting Requirements

If a treatment is required:	Then:
As a result of a pest interception	GO to Step 2
As a condition of entry	GO to Step 3

Step 2—Issuing a PPQ Form 523 (Emergency Action Notification)

When an intercepted pest is identified and confirmed by a PPQ Area Identifier as requiring action, issue a PPQ Form 523 (Emergency Action Notification) to the owner, broker, or representative. Be sure to list all treatment options when completing the PPQ Form 523 (Emergency Action Notification). Follow instructions in Appendix 1 for completing and distributing the PPQ Form 523 (Emergency Action Notification).

Step 3—Determining Section 18 Exemptions and Sampling Requirements

After selecting the treatment schedule, you will be able to determine which treatment schedules are FIFRA Section 18 Exemptions by the presence of broad, bold, vertical lines on the borders of the treatment schedule table listed in the reference. Some treatment schedules are only FIFRA Section 18 Exemptions at specific temperature ranges. Check the treatment schedule and temperature to determine if the fumigation will be a FIFRA Section 18 Exemption.

Food or Feed Fumigations

Residue monitoring by taking samples of the commodity prior to the start of the fumigation and after aeration is no longer required.

Step 4—Selecting a Fumigation Site

Consider the following factors in selecting a fumigation site:

- ◆ A well-ventilated, sheltered area
- ◆ Ability to heat area (in colder areas)
- ◆ An impervious surface

- ◆ A nonwork area which can be effectively marked and safeguarded or isolated
- ◆ Electrical power supply
- ◆ Water supply
- ◆ A well-lighted area
- ◆ Aeration requirements

A Well-Ventilated, Sheltered Area

Select sites which are well-ventilated and in a sheltered area. A well-ventilated site is required for exhausting gas before and when the tarpaulin is removed from the stack. Most piers and warehouses have high ceilings and a number of windows/doors which can be used for ventilation. Some gas will escape from the tarpaulin even in the best conditions. Avoid areas where strong drafts are likely to occur.

In warehouses, an exhaust system must be provided to exhaust MB to the outside of the building. Ensure that the exhausted gas does not reenter the building nor endanger people working outdoors.

When treatments are conducted in a particular location on a regular basis, a permanent site should be designated. At such sites, the fan used to remove the fumigant from the enclosure during aeration must be connected to a permanent stack extending above the roof level.

If fumigations are conducted outside, select a site that is semi-sheltered such as the leeward side of a warehouse, pier, or building that offers some protection from strong winds.

Ability to Heat Area

When cooler temperatures (below 40 °F) are expected, the site must be heated to maintain commodity temperatures above 40 °F. Take the ambient temperature 12 inches above the floor.



Do not use flame or exposed electrical element heaters under the tarpaulin during treatment because MB may cause the formation of hydrogen bromide. Hydrogen bromide (hydrobromic acid) is a highly corrosive chemical which can cause damage to the heater and to surrounding materials including the commodity. Hot air or radiator type heaters can be used for heating under tarpaulins. When using space heaters to heat warehouses, there must be adequate ventilation.

An Impervious Surface

Select an asphalt, concrete, or tight wooden surface—not soil, gravel, or other porous material. If you must fumigate on a porous surface, cover the surface with asphalt (tar) paper or plastic tarpaulins. For large fumigations, covering the surface is not usually practical because pallets must be rearranged and heavy equipment used to move the commodity. On docks, wharfs, and piers, check for cracks, holes, and manhole covers which will allow the MB to escape through the floor. Have all cracks, holes, and manhole covers sealed with plastic or asphalt paper.

- A Nonwork Area** Select a secure area where traffic and people are restricted from entering and which is isolated from people working. You want a nonwork area to help prevent accidents such as a forklift piercing a tarpaulin and for other safety reasons. Consider either the entire structure area or an area which extends 30 feet from the tarpaulin and is separated by a physical barrier such as ropes, barricades, or walls as the fumigation area. If a wall of gas-impervious material is less than 30 feet from the tarpaulin, the wall may serve as the edge of the secured area. Some states, for example California, require a 100 foot buffer zone. Place placards clearly in sight of all who come near. Placards must meet label requirements regarding specific warnings, information, and language. Placards generally include the name of the fumigant, the fumigation date, time, and the name of the company conducting the fumigation. Restrict access to the fumigation area to the fumigator's employees and PPQ employees monitoring the treatment. Use rope or marker tape to limit access within 30 feet of the enclosure. Do not allow motor vehicles (includes forklifts) to operate within 30 feet of the enclosure during the fumigation and aeration periods. The area outside the 30-foot perimeter is usually regarded as a safe distance from the tarpaulin. Gas concentrations exceeding 5.0 ppm (TLV for MB) are seldom recorded by gas monitoring, except during aeration. PPQ Officers that work within the 30-foot perimeter must wear (and use) respiratory protection (SCBA), unless the gas levels are safe to breath and validated as safe by gas monitoring. The 30-foot perimeter is not specifically mentioned on the MB label, but is required for PPQ Officers. When space is tight, it is permissible to overlap two adjoining 30-foot perimeters. However, there must be sufficient space for a person wearing SCBA to walk between the tarpaulins.
- Electrical Power Supply** An adequate electrical source must be available to run the circulation fans and the T/C unit. A separate line should be available for the T/C unit. Electrical outlets must be ground and conveniently located in relation to the fumigation area. Do *not* use generators as a power source, except under emergency conditions.
- Water Supply** A water supply is necessary for safety purposes. Water is necessary for washing off MB if the liquid form is spilled on someone. Water is also used to fill the volatilizer. If no permanent water is present on site, the fumigator must provide a portable, 5-gallon supply of clean water.
- Well-Lighted Areas** The area should have adequate lighting for safety purposes and for ease in reading T/C units, thermometers, and for determining whether a tarpaulin has holes or tears.
- Aeration Requirements** Assuming that you've already restricted access and secured the fumigation area, you now must restrict access to the area where the exhaust duct extends beyond the enclosure. Before you start a fumigation, make sure the exhaust duct is located in a safe place.

During the first 10 minutes of aeration, there should be no people within 200 feet down wind of the exhaust duct outlet. If the exhaust duct is not used, then the requirement for a 200 foot down-wind buffer zone does not necessarily apply. However, personnel in the immediate area should be aware that a release of fumigant gas is about to take place and given the option of wearing SCBA if they choose to continue working in the area. If it is impossible to restrict people from the area of aeration during regular work hours, consider aeration during another time of the day. When securing the duct outlet area, consider the direction of the wind. Face the duct outlet toward an open area, and away from people. Point the duct outlet upward to aid in dispersing the exhausted gas.

After the first 10 minutes of aeration, if an exhaust duct is not used, then a perimeter of 30 feet or more from the stack is usually regarded as a safe distance for personnel. However, for personal safety, gas levels should occasionally be monitored at greater distances, especially downwind. Experience provides the best guide.

Step 5—Arranging the Stack

Break Bulk Cargo

Have the cargo arranged in a square or rectangular shape, if possible, to make it easy to cover and to calculate the volume of the stack. An even shaped stack is easy to tarp. The height of the stack should be uniform so dosage can be calculated accurately. For loose cargo, the tarpaulin should be 2 feet above the load and one foot from the sides and ends. Unless specified in the treatment schedule, cargo should not exceed two-thirds of the volume of the area to be fumigated. The maximum size for an enclosure is 25,000 ft³. Contact the Oxford Plant Protection Laboratory to get approval for any enclosures larger than 25,000 ft³. For very large enclosures, it may be necessary to:

- ◆ install extra circulation fans
- ◆ add more sampling leads
- ◆ introduce the fumigant at several sites, using multiple volatilizers
- ◆ run the circulation fans longer than just the first 30 minutes, if the difference between the highest and lowest gas concentration readings exceeds 4 ounces

Once Oxford has approved the site and enclosure, it does not require additional approvals for subsequent fumigations. The commodity should be on pallets to permit air movement along the floor and between the cargo. Allow an inch or more of space between pallets. By arranging the stack evenly and with space between pallets or cartons, the fumigant will be effectively distributed and dosage calculation should be easier and more accurate. Dosages are easier to calculate when the dimensions are uniform.

Containerized Cargo

When the fumigation involves multiple stacks, allow 10 feet of space between each uncovered stack. After the stack is tarped, there should be approximately 5 feet between enclosures.

Place no more than eight containers that are 20 to 40 feet in length under a single tarpaulin. APHIS recommends that containers not be stacked. Stacking may create too great a safety risk to the person placing the tarp, fans, and gas monitoring leads. If fumigating multiple containers in a single row, have all the rear doors opening on the same side. If multiple containers are placed in two rows, then have all the doors opening on a center aisle toward each other (See [Figure 2-4-1](#)). The aisle must be at least 3 feet wide. The aisle must be at least 3 feet wide. All doors should be completely open, if possible.

However, APHIS will allow fumigation of containerized cargo with one door open on each container using a configuration such as the one shown in [Figure 2-4-2](#), or in a single row of eight containers. Gas should be introduced at both ends of this long row configuration, either at the same time or half at one end and half at the other end. In any case, the single open door on each container must be kept from closing during the fumigation, either taped or blocked open.



APHIS recommends that perishable commodities be fumigated outside their containers. Because it is difficult to aerate the container, the commodity may be damaged by the fumigant if left in the container. Therefore, it is best to remove perishable commodities from their containers before fumigation. When a commodity is removed from the container, spray the emptied container with Malathion as a precaution against leaving the container contaminated with live pests. Pests such as hitchhikers may not remain with the commodity.

However, because of the cost of devanning the commodity most importers choose to have their commodity fumigated inside the container.

Due to safety considerations, containers to be fumigated should not be stacked. Also, to conserve methyl bromide use, the Oxford Plant Protection Laboratory recommends that containers be removed from their chassis prior to fumigation. (If this is not done, then the space beneath the container must be calculated as part of the total volume being fumigated.)

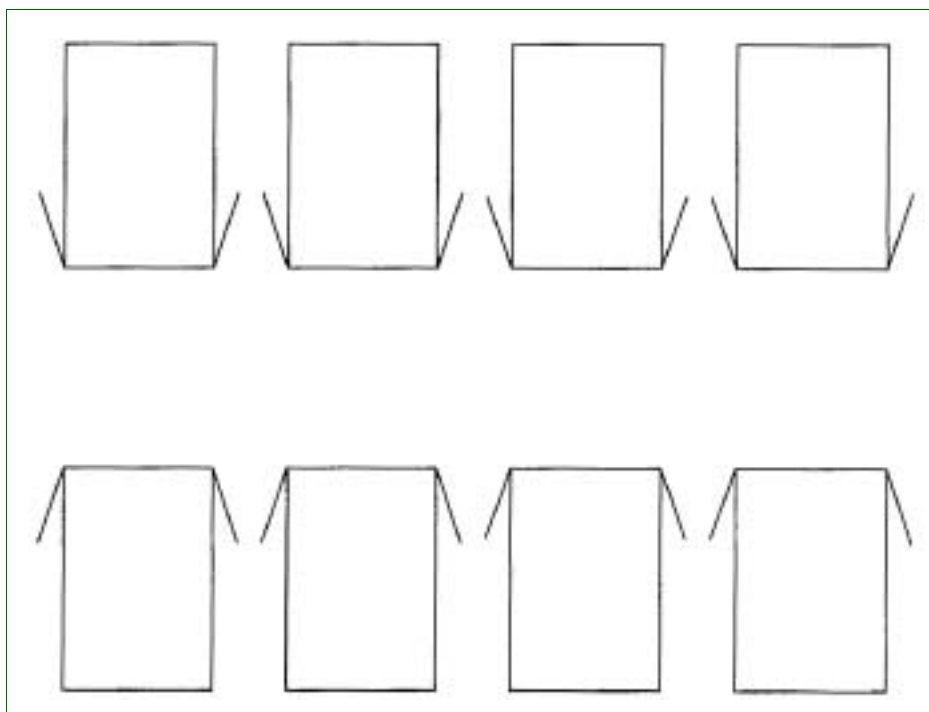


FIGURE 2-4-1: Container Arrangement in Two Rows

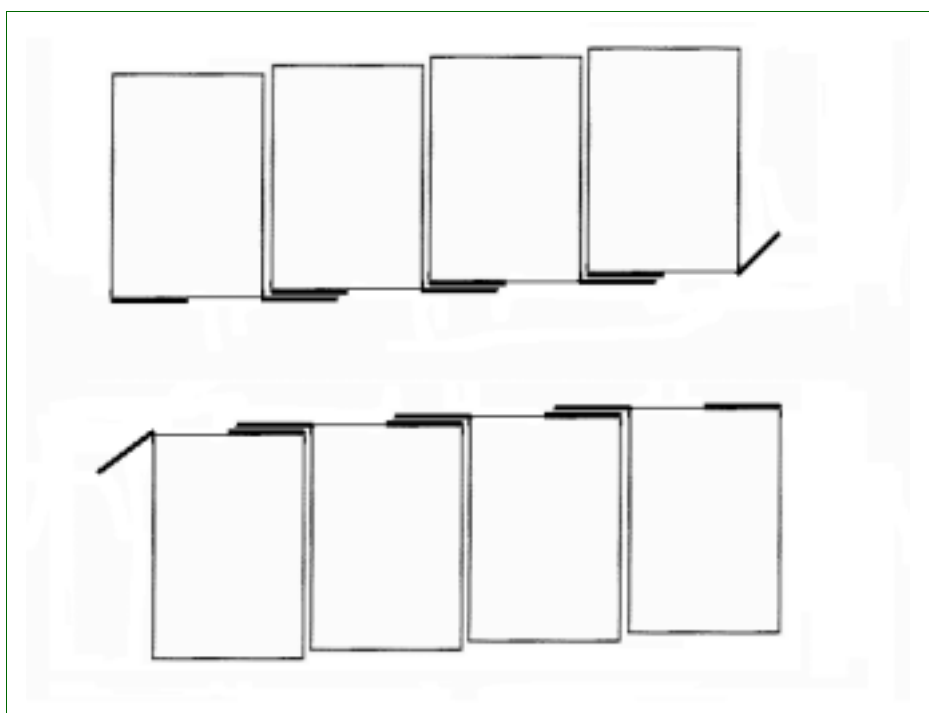


FIGURE 2-4-2: Container Arrangement in Two Rows

Containers should ordinarily not be loaded beyond 80 percent of their capacity. A space of 20 percent (18 inches) should be provided above the commodity. This allows a crawl space for placing the gas

monitoring leads and fans, and to facilitate uniform gas distribution. (Some restacking of cargo may be necessary to meet this requirement.) Adequate space (2 inches) should be provided below the commodity. No additional head space is required between the roof of the container and the tarp, unless the pest is found on the outside of the container.

If fumigating multiple containers in a single row, the rear doors should all open on the same side of the stack. If containers are parked parallel to one another and close together, it is permissible to open only the door on the right side of each container, overlapping and taped to the closed left door of the container adjacent to it. In such circumstances, however, one must have a fan positioned high, blowing into the open door of each container, to assure uniform fumigant distribution. If containers are not parked closely together, all doors must be completely open.

Gas Penetration and Distribution

MB will penetrate most cargo easily. When fumigating finely milled products (such as flour, cottonseed meal, and baled commodities), provide space every 5 feet in any direction. Penetration is enhanced by the availability of free MB.

Some of the more common types of impermeable materials are cellophane, plastic, wax coated materials, laminated, and waterproofed papers. Tight wooden packing cases are also relatively gastight. Impermeable materials will allow some gas to penetrate, but make it difficult to aerate and evacuate the gas. Remove, perforate, or open all impermeable materials.

For impermeable wrappers or containers, open the entire top or side and place the package with the open portion on the side.

Step 6—Arranging and Operating Fans

Break Bulk Cargo

Use fans which have the capacity to move a volume in cubic feet per minute equivalent to the total volume of the enclosure. For a 5,000 ft³ enclosure, use two axial-type (blade) fans of approximately 2,500 cfm. Place one fan on the floor at the rear of the stack facing the front and the other fan at the top front (where the gas is introduced) facing the rear. For enclosures from 5,000 to 7,500 ft³, add a third fan near the upper middle facing the rear. For enclosures from 7,501 to 10,000 ft³, add a fourth fan on the floor near the middle facing the front. Enclosures from 10,001 to 25,000 ft³ may require up to seven fans to provide adequate gas circulation. Enclosures larger than 25,000 ft³ require approval from the Oxford Plant Protection Laboratory.

Turn on all fans to make sure they work. Operate fans during gas introduction and for 30 minutes after the gas is introduced. If after taking gas concentration readings the fumigant is not evenly distributed, run the fans until the gas is evenly distributed as

indicated by concentration readings (within 4 oz. of each other). Operate fans when adding gas, but only long enough to get even gas distribution.

Containerized Cargo

Use an appropriate number of fans which have the capacity to move the equivalent cubic feet per minute of the total volume of the enclosure. In addition, place one additional fan of at least 2,500 cfm at the top of the load (near door) of each container facing the opposite end of the container.

Place air introduction ducts, for aeration, into the far ends of each container. Also, place exhaust ducts on the ground in front of the end doors of the containers. Place the end of the ducts near the edge of the tarpaulin so they can be pulled under the tarpaulin when aeration begins.

Step 7—Placing the Gas Introduction Lines

Break Bulk Cargo

Place the gas introduction line directly above the upper front fan. Attach the line to the top of the fan to prevent movement of the hose. An unsecured introduction line could tear the tarpaulin, move the line, or direct it out of the airflow. The fan should be firmly attached to the cargo or have a base that prevents it from toppling (not a pedestal type). Place a piece of impermeable sheeting (example—plastic or rubberized canvas) over the commodity below and to the front of each gas supply line. The sheet will prevent any liquid MB from coming in contact with the cargo.

Containerized Cargo

The number and placement of gas introduction lines will depend upon the number and arrangement of containers to be fumigated.

For single containers, place the introduction line directly above the fan near the rear door of the container.

For multiple containers, place the introduction line near the door end of the containers, but aimed across the open doors rather than directly into one container.

If you are fumigating four or more containers under one tarpaulin, then use two gas introduction lines.

Step 8—Placing the Gas Sampling Tubes

Break Bulk Cargo

Place a minimum of three gas sampling tubes for fumigations up to 10,000 ft³. Position the gas sampling tubes in the following locations:

- ◆ Front low—front of the load, 3 inches above the floor
- ◆ Middle center—center of the load, midway from bottom to top of load
- ◆ Rear high—rear of the load, at the extreme top of the load

See **Figure 2-4-3**

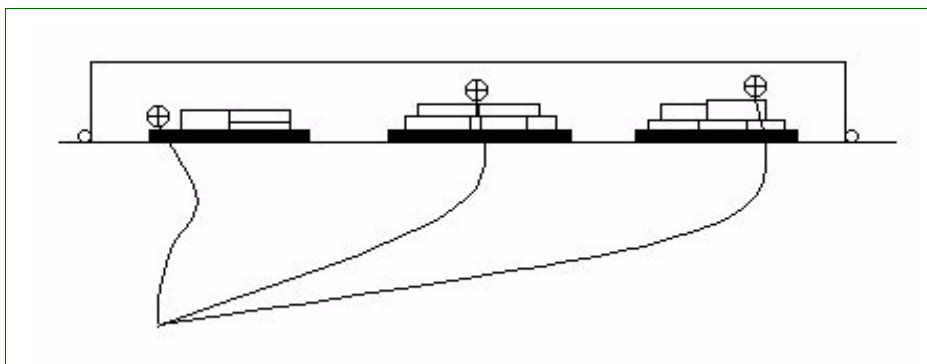


FIGURE 2-4-3: Gas Lead Position (Side View)

For fumigations from 10,001 to 25,000 ft³, use six gas sampling tubes. Position the gas sampling tubes in the following locations:

- ◆ Front low—front of the load, 3 inches above the floor
- ◆ Upper front quarter section
- ◆ Middle center—center of the stack, midway from bottom to top
- ◆ Upper rear quarter section
- ◆ Lower rear quarter section
- ◆ Rear high—rear of the stack, at the extreme top

Contact the Oxford Plant Protection Laboratory for approval of fumigations larger than 25,000 ft³, for instructions for number of gas sampling tubes, and for other technical information.



For khapra beetle cargo containing baled, packaged, finely milled, or closely packed commodities, place two additional gas sampling tubes in the center of the bags, packages, or bales. Before placing gas sampling tubes in commodities, place burlap over the end of the tube and secure the burlap to the tube with tape.

Containerized Cargo

For multiple containers (either 20 or 40 feet in length) under the same tarpaulin, use at least three tubes per container. Also, for single containers, use at least three tubes, and for khapra beetle infestations, use two additional tubes. Position the gas sampling tubes as follows:

- ◆ Front low—near the floor at the door end of the container
- ◆ Rear high—rear of the load at the high end opposite the fan
- ◆ Middle center (use only for single container fumigation)

If treating commodities for khapra beetle, you will need the following additional gas sampling tubes:

**Break Bulk and
Containerized
Cargo**

- ◆ High (in the commodity)
- ◆ Low (in the commodity)

Cover the end of the gas sampling tube with burlap taped to the tube before insertion into the commodity.

Use gas sampling tubes of sufficient length to extend from the sampling position inside the enclosure to at least 30 feet beyond the tarpaulin. Have all the gas sampling tubes meet in one area for ease and safety in taking gas concentration readings. Do not splice gas sampling tubes. Before starting the fumigation, test all gas sampling tubes for tightness by connecting each gas sampling tube to the T/C unit and placing a finger over the far end of the gas sampling tube. The ball in the flow meter will fall to zero if the gas sampling tube connections are tight. Replace any defective gas sampling tubes. Before starting the fumigation, check for gas sampling tube blockage or pinching by connecting each tube for a short time. If the tube is blocked, the flow meter will drop sharply.

Fix all gas sampling tubes securely in place under the tarpaulin and label each one at the end where the gas concentration readings will be taken. By labeling each gas sampling tube, you will be able to record concentration readings easily.

Step 9—Padding Corners

Look for corners and sharp angles which could tear the tarpaulin. Never use commodity to support the tarpaulin. If the sharp angles or corners can not be eliminated, they must be covered with burlap or other suitable padding (example—old tires or cloth). (See [Figure 2-4-4](#) below.)

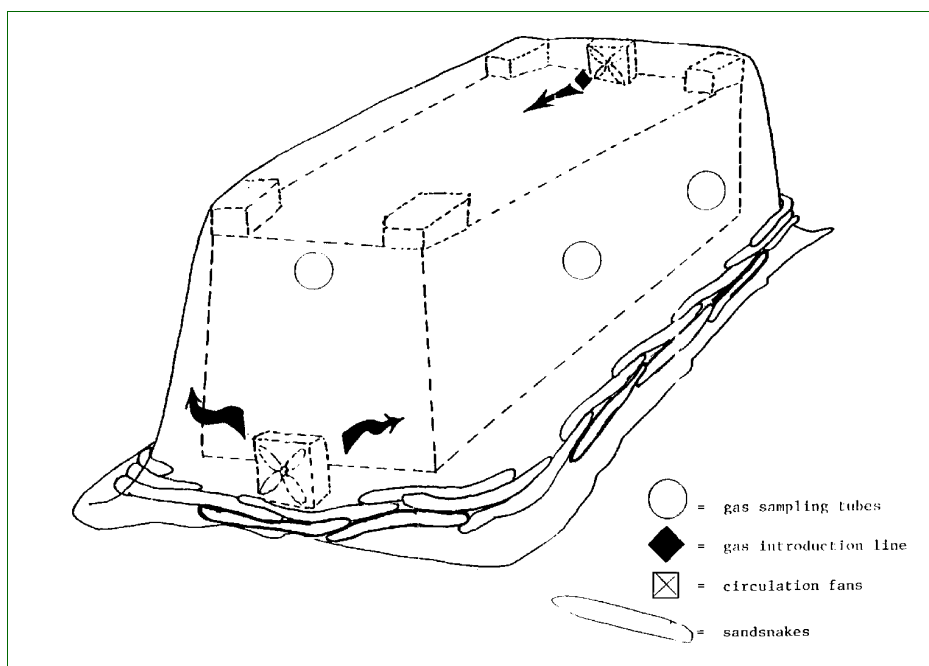


FIGURE 2-4-4: Typical Stack Arrangement with Fans, Leads, Introduction Line, Padding, and Sand Snakes

Step 10—Measuring the Temperatures



Regardless of the commodity, never fumigate at temperatures below 40 °F.

Temperature recordings should be rounded to the nearest tenth of a degree (C ° or F °)

Determine the temperature to use in selecting the proper dosage rate:

- ◆ For fruits, pulpy vegetables, or logs use only the commodity temperature.
- ◆ For all other commodities use both the commodity and air temperature.

To take the temperature readings, use a bimetallic, mercury, or digital long-stem thermometer that has been calibrated. Use [Table 2-4-2](#) to determine which temperature to use when selecting the proper dosage rate for commodities other than fresh fruits, vegetables, or logs.

TABLE 2-4-2: Determine the Temperature for the Proper Dosage Rate

If the air temperature is:	And:	Then, for commodities other than fresh fruits or pulpy vegetables or logs and lumber:
Higher than the commodity temperature	→	Use the single lowest commodity temperature for determining the dosage rate (Do Not use the average commodity temperature).
Lower than the commodity temperature	By 9 degrees or less	Use the average of the single lowest air and commodity temperatures for determining the dosage rate (Never initiate a fumigation if any commodity temperature reads lower than 40°F.)
	By 10 degrees or more	

EXAMPLE: You are about to fumigate guar gum and the commodity temperature is 82 °F and the air temperature is 69 °F. Average the air and commodity temperatures to determine the dosage rate because the air is 13 degrees lower than the commodity temperature. The average of the two temperatures is 75.5 °F. Use 75 °F to determine the dosage rate.

If the commodity is fruits, pulpy vegetables, or logs, see the specific procedures that follow.

Fresh Fruits and Pulpy Vegetables

For fresh fruit and pulpy vegetables, insert the thermometer into the pulp. (for purposes of this paragraph, peppers are also included in the category of pulpy vegetables.) For commodities which have been refrigerated, probe the fruit that have the lowest pulp temperature. Again, fumigate only when the fruit pulp is at 40 °F or higher.

However, if the commodity has no pulp (for example, peas, beans, grains, herbs, spices, etc.), take the temperature of the air space immediately surrounding the commodity as well as the commodity temperature. With these temperatures, use **Table 2-4-2** to determine the correct temperature for use when selecting the proper dosage rate.

Logs and Lumber

Insert the thermometer into a crack or drill a hole 2 inches in depth in several representative locations within the stack. Wait at least 10 minutes, take temperature readings in each hole, and average the readings. All readings must be above 40 °F.

Take temperature readings in each hold. Base the dosage calculation on the lowest reading obtained. (Do not average temperatures.) All readings must be above 40°F to initiate the fumigation. If not, you must postpone it.

Record the temperatures in Block 22 of the PPQ Form 429.



When the commodity and air temperature drastically differ, moisture may condense inside the gas sampling tubes or inside the T/C unit and cause inaccurate gas concentration readings. Check the gas sampling tubes frequently for possible puddling of condensed water, and drain it off, as needed, before taking a reading. Also, check the Drierite frequently, and change it as soon as it becomes saturated with water [turns pink], to obtain true gas concentration readings. Never fumigate commodities that are frozen.

Step 11—Covering the Stack

After covering the stack, check the tarpaulin for rips, tears, and holes. Look at the spots that have been taped, and verify they are properly sealed. Have the fumigator repair all holes.

The tarpaulin should be made of a material such as vinyl, polyethylene plastic, or coated nylon. 4 mil vinyl or polyethylene plastic tarpaulins are only approved for one usage; 6 mil vinyl or polyethylene plastic tarpaulins may be used up to four times with the officer's approval for each usage; 10 to 12 mil rubber or plastic coated nylon tarpaulins may be approved for multiple use with the officer's approval for each usage.

The fumigator should cover all corners and sharp ends with burlap or other padding to prevent the tarpaulin from ripping. Have the fumigator pull the tarpaulin over the stack, being careful not to catch or tear the tarpaulin. Make sure there is sufficient structural support to raise the tarpaulin 2 feet above and 1 foot beyond the sides of the commodity.

The tarpaulin must be large enough to provide a floor overlap of at least 18 inches around all sides of the stack. Carefully lay the tarpaulin out to prevent excess folds or wrinkles along the floor, especially around corners.



Sealed containers and vans cannot be considered as "fumigation chambers," and therefore **must be covered by a tarpaulin**, unless they can pass the pressure-leakage test.

However, refrigerated containers (reefers) may be fumigated without a tarpaulin if specific requirements are met. See "Special Procedures for Container Fumigations Without a Tarpaulin."

Step 12—Sealing the Tarpaulin

Sealing may be accomplished with loose, wet sand, sand snakes, water snakes, adhesives, or a combination. If there is danger of crushing or crimping the gas sampling or introduction tubes, use the loose, wet sand. If using snakes, use two rows of snakes along the sides and three rows on the corners. The snakes should overlap each other by approximately 1 foot. The goal in sealing the tarpaulin is to get the tarpaulin to lie flat against the floor to prevent gas from leaking out.

When wind is not a factor, plastic tape may be used for sealing the tarp. The tarp must be at least 2 inches in width, and applied (only to a smooth surface) with the aid of high-tack spray adhesive.

Seal corners by laying two sand snakes around the corner and working the tarpaulin until it is flat. Place a third snake on top of the two other snakes to provide additional weight to force the tarpaulin against the floor. Loose, wet sand can be used in the area where the gas introduction line, electrical cords, and gas sampling tubes extend from under the tarpaulin.

Step 13—Measuring the Volume

Using a 100-foot tape measure, carefully measure the length, width, and height of the enclosure. *Never* estimate the measurements. An error in measurement of as little as 12 inches can result in miscalculation of the dosage by as much as 15 percent. When measuring, round off to the nearest quarter foot (example—3 inches = .25 feet). In the case of fumigations of edible commodities, an error can result in an unacceptable level of residue on the commodity. If the sides of the enclosure slope outward from top to bottom, measure both the top and bottom and average the two to determine the dimension. Enclosure height should always be uniform and not require adjustment.

Formula for determining volume:

Length × width × height = volume in cubic feet

EXAMPLE: A stack with measurements H=10'6", L=42'3", and W=10'9" $10.50 \times 42.25 \times 10.75 = 4,768.9 \text{ ft}^3$ round to 4,769 ft^3

Record volume in Block 26 of the PPQ Form 429.

Step 14—Calculating the Dosage

Calculate dosage by doing the following:

1. Refer to the treatment schedule for the correct dosage rate (lbs./1,000 ft^3) based on temperature (°F) (Step 10).
2. Multiply by the dosage (lbs./1,000 ft^3) rate by the volume (ft^3) to get the dosage in pounds.
3. Rules for rounding. Round to nearest 1/4 pound.

Formula for calculating dosage:

$$\begin{aligned} \text{dosage (lbs.)} &= \text{volume}(\text{ft}^3) \times \text{dosage rate (lbs./1,000 ft}^3) \\ &= \frac{\text{volume}(\text{ft}^3) \times \text{dosage rate (lbs.)}}{1,000 \text{ ft}^3} \end{aligned}$$

EXAMPLE: You need to determine the dosage for a stack with a volume of 3,000 ft³. For 72 °F (air and commodity temperatures), the treatment schedule lists the dosage rate at 2 pounds MB/1,000 ft³. Determine dosage by doing the following:

1. Volume = 3,000 ft³
2. Dosage rate = 2 lbs. MB/1,000 ft³
3. Dosage (lbs.) = volume (ft³) × dosage rate (lbs./1,000 ft³)
= 3,000 ft³ × 2 lbs. MB/1,000 ft³
= $\frac{3,000 \text{ ft}^3 \times 2 \text{ lbs. MB}}{1,000 \text{ ft}^3}$
= 6 lbs. MB

Step 15—Making a Final Check

Just prior to introducing the gas, do the following:

- ◆ Turn on all fans and T/C unit to make sure they work.
- ◆ Warm up T/C unit at least 30 minutes before zeroing in.
- ◆ If contaminant, CO₂, is detected, test again with Ascarite[®]. If you get a zero reading, proceed. If you don't get a zero reading, suspect a leak.
- ◆ Start volatilizer and heat water to 200 °F or above. A minimum temperature of 150 °F is required at all times during the introduction process.
- ◆ Place fumigant cylinder with gas introduction line on scale and take initial weight reading. Make sure the gas introduction line is attached to the cylinder. After obtaining the correct weight, subtract the dosage to be introduced into the enclosure. After you have introduced the proper amount of gas, the scale will be balanced.
- ◆ Check that tarpaulin is placarded and the area is secured. Only people working on the fumigation may be in the area.
- ◆ Check tarpaulin to make sure it is free from rips and tears.
- ◆ Check that all gas sampling tubes are labeled and are not crimped or crushed. Inspect tubes visually, or use an electric or Mityvac hand pump to check tubes. Either a fumiscope or vacuum pump may be used to test leads for unrestricted flow.



When conducting fumigations with methyl bromide, sulfuryl fluoride or phosphine, erroneous readings may occur if the monitoring leads become blocked or crimped. It would be impossible to install a new monitoring lead during a fumigation treatment. Therefore, to avoid an unsuccessful fumigation, you should test monitoring leads before the treatment begins.

Oxford Plant Protection Laboratory has developed the following procedure to detect blocked monitoring leads with the use of a Mityvac hand-held pump (for supplier, see [Vacuum Pump, Appendix H](#)):

1. Prior to fumigant introduction, connect the Mityvac hand-held vacuum pump to a monitoring lead.
2. Squeeze the handle on the Mityvac unit. If the lead is blocked, a vacuum will be indicated on the vacuum gauge of the Mityvac unit. (The handle should be squeezed two or three times for monitoring leads longer than 25 feet. The Mityvac hand-held pump has the capacity to attain and hold 25 inches of Hg vacuum and a minimum of 7 psig pressure.)
3. Disconnect the Mityvac hand-held pump from the monitoring lead, and repeat this procedure for each monitoring lead. (Connect monitoring leads to the gas analyzer prior to fumigant introduction.)

- ◆ Check that there is enough gas in the cylinder and if necessary, that other cylinders are available.
- ◆ Check the gas introduction line connections to make sure they are tight and free of leaks (wearing the SCBA).
- ◆ Check all safety equipment, especially SCBA, is available and in working order.
- ◆ Install Drierite[®] tube on gas sample line attached to the T/C unit and check to make sure granules are blue, if pink—replace Drierite[®]. If humidity is high, additional Drierite[®] tubes or frequent changes may be necessary.

Conducting the Fumigation

Step 1—Introducing the Gas



The acceptable air concentration level for methyl bromide (MB) is 5 ppm. A respirator (approved SCBA or MSHA/NIDSH) is required if the MB concentration level in the air is greater than 5 ppm at any time. You and the fumigator must use your SCBA while introducing the gas, checking for leaks, and when taking aeration readings.

Turn on all fans before introducing the gas. When using large cylinders of MB, have the fumigator open the cylinder valve slightly, then close the valve. With a halide detector, check all connections on the gas introduction line for leaks. If leaks are found, advise the fumigator to tighten the connections and repeat the test. If no leaks are found, then open the valve to the point where 3 to 4 pounds of MB

are being introduced per minute. The water temperature in the volatilizer should never go below 150 °F at any time during gas introduction. The water in the volatilizer may include an antifreeze and should be handled with the appropriate safeguards.



Don't touch the introduction line with your bare hands—you could get burned! Close the cylinder valve once the proper dosage has been introduced.

The fumigation time begins once all the gas has been introduced. Record the time gas introduction was started and completed in Block 32 on the PPQ Form 429. Run the fans for 30 minutes to achieve even gas distribution. Take the initial concentration reading 30 minutes after all the gas has been introduced.

When evacuating large cylinders, getting the final amount of gas out may take a long time. Consider taking a T/C unit reading 30 minutes after the gas was first introduced. If the gas distribution is even (all readings within 4 ounces of each other) and at a significantly high concentration, then turn off the fans. Running the fans longer may contribute to gas leakage. Allow the remainder of the gas to discharge with intermediate running of the fans. Normally, all the gas should be introduced within 30 minutes.



Do **not** begin counting fumigation time until all the gas has been introduced and valve on the MB tank is closed.

Step 2—Testing for Leaks

Wear the SCBA while checking for leaks. Use a halide detector to test for leaks before the 30 minute reading or anytime when the concentration level is unknown or above 5 ppm. Test around the perimeter of the tarpaulin on the floor, corners, and especially where electric cords, gas sampling tubes, or gas introduction lines are present. When you detect leaks, have them sealed using more sand or sand snakes for floor leaks and tape for sealing small holes in the tarpaulin.

If you detect excessive leakage (concentration readings of 50 percent or less of the minimum concentration) in a tarpaulin which cannot be corrected in a practical way, do not attempt to correct the problem by adding more gas. Quickly evacuate the remaining gas from the enclosure, eliminate the problem, and construct a new enclosure. Aerate as usual following procedures on [page-2-2-3](#). Restart the fumigation in the new enclosure.



Commodities used for food or feed may not be re-treated. If commodities fall into this category, the only options are the following:

- ◆ Return to the country of origin
- ◆ Re-exported to another country if they will accept the shipment
- ◆ Destroy by incineration

Step 3—Taking Concentration Readings



Before taking a reading, always purge sampling lines with a mechanical or hand pump. After connecting the T/C unit to the sampling lead, always adjust the gas flow rate to 1.0, and wait until the meter registering "ounces per thousand cubic feet" stabilizes before taking a reading. (This may take a minute or more, depending upon the length of the tubing and whether or not an auxiliary pump is used.). If you're using treatment schedule T101 or [T401-a](#) to fumigate fresh fruit or vegetables, see "Special Procedures for Fruits, Vegetables, or Perishable Commodities Using Schedule [T101-a-1](#) or Equivalent" on [page-2-4-28](#).

Take concentration readings with a T/C unit to determine the gas concentration and distribution within the enclosure. Check desiccant tubes before each reading and change Drierite[®] if its color is pink. Depending upon the length of exposure period, take concentration readings at the following times:

- ◆ 30 minutes
- ◆ 2 hours
- ◆ 4 hours (optional)
- ◆ 6 hours (optional)
- ◆ 12 hours (optional)
- ◆ 24 hours⁵
- ◆ 36 hours (optional)
- ◆ 48 hours
- ◆ 72 hours

Any final concentration reading (see following example)

EXAMPLE: If the treatment schedule lists a 6 hour exposure period, then the 6 hour reading would be required and not optional as shown in step 3. If the treatment schedule lists a 16 hour exposure period, you must take a 16 hour reading.

⁵ If fumigating oak logs or lumber for export, see "Special Procedures for Adding Gas to Oak Logs and Lumber."



Avoid using hand-held two-way radios near the T/C unit. Using two-way radios near the T/C unit will interfere with an accurate concentration reading.

Thirty Minute Reading

The 30 minute reading shows the initial concentration and distribution of gas. The 30 minute reading can indicate leakage, sorption, incorrect dosage calculation, or error in fumigant introduction—all of which require immediate attention. Concentration readings should not differ more than 4 ounces among the leads.

Two Hour Reading

In comparison with the 30 minute reading, the 2 hour reading also will indicate if the tarpaulin is leaking or the commodity is sorbing gas. Readings more than 15 percent lower than the 30 minute reading will require close monitoring and possible corrective action.

EXAMPLE: Your dosage for the fumigation was 4 pounds (64 ounces). The 30 minute reading was 50 ounces (3.125 pounds). The 2 hour reading is 42 ounces (2.625 pounds). The 2 hour reading is more than 15 percent less than the 30 minute reading and would indicate that either a leak or sorption problem may exist. You would need to monitor the fumigation closely until the concentration level stabilizes.

Four, Six, Twelve, or Thirty-Six Hour Reading

Not required if previous readings are satisfactory and experience with similar fumigations indicate successful treatment can be expected. If either the 4, 6, 12, or 36 hour reading is the final reading, then you must take the reading. If you are unfamiliar with the treatment schedule, optional concentration readings may be necessary to ensure a successful fumigation.

Final Reading

The final reading is required for all tarpaulin fumigations in order to determine if the fumigation has been successfully completed. You may start the final reading before the finishing time of the treatment so that aeration commences at the finishing time. Starting the final reading before finishing time is especially critical when fumigating perishables. Do not add gas after the final reading.

Additional Readings

Decide the need to take additional readings based on the following:

- ◆ Rate of gas concentration decrease
- ◆ Any condition which could change the gas concentration such as severe winds, or rain.

When concentration readings differ by more than 4 ounces, run the fans to equalize the gas and record readings on the APHIS 429. Generally, at the 1/2 hour reading, gas should be evenly distributed, and you should not have to restart the fans unless you added gas.

Severe winds (30 mph or higher including any amount severe enough to cause damage) are a good reason to take additional readings on an outdoor fumigation. Any sharp or unusual decreases of the readings in relation to previous readings is a clue to take corrective action and supplementary readings. Take additional readings every 30 minutes until problems are rectified. Adverse weather conditions may indicate the need for additional readings.

Sorptive commodities may also require additional concentration readings.

Step 4—Determining the Need to Add Gas and Adjust Exposure

Use the following table to determine when to add gas or extend the exposure period:

TABLE 2-4-3: Determine the Need to Add Gas and Adjust Exposure

If the average T/C unit readings are:	And the schedule is:	Then:
Below the required minimum concentration	T101-a-1* or equivalent	ADD gas and extend fumigation. SEE “Special Procedures for Fruits, Vegetables, or Perishable Commodities Using Schedule T101-a-1 or Equivalent” on page-2-4-25
	Other than T101-a-1 or equivalent	ADD gas using “Special Procedures for Adding Gas to Oak Logs and Lumber Using T312 or Equivalent” on page-2-4-28
At or above required minimum concentration	T101-a-1* or equivalent	SEE pages page-2-4-21 for corrections at 0.5 hour and 2 hour readings
	Other than T101-a-1	No action necessary



* T101-a-1 or equivalent treatment schedules are those schedules that are not greater than 2 hours long (exposure time), and the dosage rate is not greater than 4lbs per 1000ft³, anywhere on the schedule.

Special Procedures for Adding Gas and Extending Exposure Period

Adding Gas to Commodities that are Fumigated Using Treatment Schedules other than T101-a-1 or Equivalent (may include perishables)



T101-a-1 or equivalent treatment schedules are those schedules that are **not** greater than 2 hours long (exposure time), and the dosage rate is **not** greater than 4lbs per 1000ft³.



To avoid injuring the commodity, add fumigant using the following formula:

$1.6 \times \text{number of oz. below minimum} \times \text{volume in ft.}^3 / 1,000 \text{ ft.}^3 = \text{oz. of gas to add}$
or $\text{oz. of gas to add} / 16 \text{ oz./lbs.} = \text{pounds (lbs.) of gas to add.}$

When adding gas, these procedures must be followed:

1. Heat water in volatilizer.
2. Turn on fans.
3. Take weight of the cylinder.
4. With SCBA on, open valve on cylinder and introduce the gas.
5. Close valve when the weight of the cylinder indicates that the needed amount of gas has been added.
6. Record quantity of fumigant added in Block 34 and the additional fan time in Block 30 of the PPQ Form 429.

Note the time the fumigator started introducing additional gas and the time the fumigator finished introducing gas and record in Block 40 (Remarks) of the PPQ Form 429. Run the fans until there is even gas distribution throughout the stack. Turn off fans, then take a concentration reading 30 minutes after the gas has been introduced. If all readings are above minimum concentration levels, then proceed as usual with the remaining scheduled concentration readings.

Excessive leakage in any one tarpaulin enclosure, which cannot be eliminated in a practical way, must *not* be corrected by the addition of MB. (Excessive leakage has occurred when concentration readings are less than or equal to 50 percent of minimum concentration reading). Quickly evacuate remaining gas from such an enclosure, eliminate the problem, and construct a new enclosure. Start a new treatment in the new enclosure.



Commodities used for food or feed may not be re-treated. If commodities fall into this category, the only options are the following:

- ◆ Re-export to another country if they will accept the shipment
- ◆ Destroy by incineration

Extending the Exposure Period for Food, Nonfood, Feed, or Nonfeed Commodities

Use the following table to determine how long to extend the exposure period.

TABLE 2-4-4: Determine the Extended Exposure Period

If the exposure time is:	And the reading is below minimum by: ¹	Then extend exposure:
Less than 12 hours	10 oz. or less	10 percent of the time lapse since the last acceptable reading
	11 oz. or more	30 minutes
12 hours or more	10 oz. or less	10 percent of the time lapse since the last acceptable reading
	11 oz. or more	2 hours or 10 percent of time lapse since last acceptable reading, whichever is greater

- ¹ If a reading is 50 percent or more below the minimum concentration reading, then abort the treatment. For example, if the minimum reading is 38 ounces then the reading 50 percent below the minimum is 19 ounces [38 ounces – (38 ounces × .50) = 19 ounces]. (See the following special procedures for fruits and vegetables using T101 or equivalent.) For oak logs and oak lumber (T312-a and T312-b), the rule for adding exposure time does not apply. Refer to the schedules for specifics.

Special Procedures for Fruits, Vegetables, or Perishable Commodities Using Schedule T101-a-1 or Equivalent

Use these instructions only for fruits and vegetables being fumigated under treatment schedule T101-a-1 or equivalent.



Fresh fruits and vegetables are sensitive to MB so you should double check volume calculations and dosage measurements to avoid accidental overdoses. If any 30 minute readings are 50 percent or more above the minimum concentration, it indicates a miscalculation of the dosage. Include a brief report on the PPQ Form 429 stating possible reasons for the overdose. Exposure periods are decreased for fumigations where concentration readings are much higher than required. See table on the following pages to determine when to reduce exposure periods.

Use **Table 2-4-5** and **Table 2-4-3** on the following pages for fresh fruits and vegetables to determine if you need to add gas or extend or decrease the exposure time. Average your concentration readings before using the tables. Select the proper table based on the time of the T/C unit concentration reading (30 minutes or 2 hours).



These tables apply **only** to those T101 schedules lasting 2 hours or less at a dosage rate of 4lbs/1000ft³ or less. They do not apply to schedules of longer duration.

Adding Gas



To avoid injuring the commodity, add fumigant using the following formula:

$1.6 \times \text{number of oz. below minimum} \times \text{volume in ft.}^3 / 1,000 \text{ ft.}^3 = \text{oz. of gas to add}$
or $\text{oz. of gas to add} / 16 \text{ oz./lbs.} = \text{pounds (lbs.) of gas to add.}$

When adding gas, these procedures must be followed:

1. Heat water in volatilizer.
2. Turn on fans.
3. Take weight of the cylinder.
4. With SCBA on, open valve on cylinder and introduce the gas.
5. Close valve when the weight of the cylinder indicates that the needed amount of gas has been added.
6. Record quantity of fumigant added in Block 34 and additional fan time in Block 30 of the PPQ Form 429.

Note the time the fumigator started introducing additional gas and the time the fumigator finished introducing gas and record in Block 40 (Remarks) of the PPQ Form 429. Run the fans until there is even gas distribution throughout the stack. Turn off fans, then take a concentration reading 30 minutes after the gas has been introduced. If all readings are above minimum concentration levels, then proceed as usual with the remaining scheduled concentration readings.

TABLE 2-4-5: Determine Gas Concentration Values and Corrections for Fruits and Vegetables at the 30 Minute Reading of T101-a-1 or Equivalent Schedules.

If the schedule is:	Add the minimum concentration reading (oz.) in schedule is:	And the average concentration reading (oz.) is:	Then:
40-49 °F 4 lbs for 2 hrs	48	73 or higher*	EVACUATE excess gas immediately
		65 or greater ¹	REDUCE exposure by 15 minutes
		64-48	TAKE 2 hour reading as scheduled
		47 or lower	1. ADD gas, and 2. EXTEND exposure 15 minutes
50-59 °F 3 lbs for 2 hrs	38	58 or higher*	EVACUATE excess gas immediately
		52 or greater	REDUCE exposure by 15 minutes
		51-38	TAKE 2 hour reading as scheduled
		37 or lower	1. ADD gas, and 2. EXTEND exposure 15 minutes
60-69 °F 2.5 lbs for 2 hrs	32	49 or higher*	EVACUATE excess gas immediately
		48 or greater	REDUCE exposure by 15 minutes
		47-32	TAKE 2 hour reading as scheduled
		31 or lower	1. ADD gas, and 2. EXTEND exposure 15 minutes
70-79 °F 2 lbs for 2 hrs	26	40 or higher*	EVACUATE excess gas immediately
		37 or greater	REDUCE exposure by 15 minutes
		36-26	TAKE 2 hour reading as scheduled
		25 or lower	1. ADD gas, and 2. EXTEND exposure 15 minutes
80-89 °F 1.5 lbs for 2 hrs	19	30 or higher*	EVACUATE excess gas immediately
		27 or greater	REDUCE exposure by 15 minutes
		26-19	TAKE 2 hour reading as scheduled
		18 or lower	1. ADD gas, and 2. EXTEND exposure 15 minutes

- 1 *If concentration reading is more than 50 percent above the minimum concentration reading, it indicates that something is radically wrong and an immediate check should be made to determine the cause and to correct it.

TABLE 2-4-6: Determine Gas Concentration Values and Corrections for Fruits and Vegetables at the 2 Hour Reading of T101-a-1 or Equivalent Schedules.

If the schedule is:	And the average concentration reading at 2 hours is:	Then do not add gas, but:
40-49 °F 4 lbs for 2 hours	38 and above	AERATE commodity (see page-2-4-29)
	37-28	EXTEND exposure by 15 minutes
	27-25	EXTEND exposure by 30 minutes
50-59 °F 3 lbs for 2 hrs	29 and above	AERATE commodity (see page-2-4-32)
	28-24	EXTEND exposure by 15 minutes
	23-21	EXTEND exposure by 30 minutes
60-69 °F 2.5 lbs for 2 hrs	24 and above	AERATE commodity (see page-2-4-32)
	23-21	EXTEND exposure by 15 minutes
	20-18	EXTEND exposure by 30 minutes
70-79 °F 2 lbs for 2 hrs	19 and above	AERATE commodity (see page-2-4-32)
	18-16	EXTEND exposure by 15 minutes
	15-13	EXTEND exposure by 30 minutes
80-89 °F 1.5 lbs for 2 hrs	14 and above	AERATE commodity (see page-2-4-32)
	13-12	EXTEND exposure by 15 minutes
	11-10	EXTEND exposure by 30 minutes

Special Procedures for Adding Gas to Oak Logs and Lumber Using T312 or Equivalent

After taking the 24 hour concentration reading, if necessary, add gas to bring the concentration level up to 240 ounces. Subtract the 24 hour concentration reading from 240 to determine how many ounces the concentration is below 240 ounces. Use the following formula in calculating how much gas to add:

$1.6 \times \text{number of oz. below 240} \times \text{volume in ft}^3 / 1,000 \text{ ft}^3 = \text{oz. of gas to add or}$

$$\frac{\text{oz. of gas to add}}{16 \frac{\text{oz.}}{\text{lbs.}}} = \text{pounds (lbs.) of gas to add}$$

EXAMPLE: You're fumigating a 10,000 ft³ enclosure of oak logs for export. At the 24 hour reading, the T/C unit readings indicate a 160 oz. concentration level. To determine how much gas to add, do the following:

$$240 \text{ oz.} - 160 \text{ oz.} = 80 \text{ oz. below 240 oz.}$$

$$1.6 \times 80 \text{ oz.} \times 10,000 \text{ ft}^3 / 1,000 \text{ ft}^3 = 1,280 \text{ oz. or}$$

$$\frac{1,280 \text{ oz.}}{16 \frac{\text{oz.}}{\text{lbs.}}} = 80 \text{ pounds (lbs.) of gas to add}$$

Take concentration readings 30 minutes after adding gas and record on the PPQ Form 429.

Step 5—Exhausting the Gas

Exhaust the gas at the completion of the exposure period. If the treatment schedule is a FIFRA Section 18 Exemption, then you must monitor the aeration of the commodity. Use the following table to determine the need to monitor the aeration of the fumigation.

TABLE 2-4-7: Determine the Need to Monitor Aeration

If the treatment schedule is:	Then:
A FIFRA Section 18 Exemption	MONITOR the aeration of the commodity. FOLLOW “Aerating the Enclosure” steps which follow.
A labelled treatment	RELEASE the commodity and RELEASE the fumigation to the fumigator for aeration.

Aerating the Enclosure

Aeration procedures are designed to provide safe working conditions during the aeration period and to assure that commodities are safe for handling, storage, and transportation. A fumigant must be aerated in accordance with Environmental Protection Agency (EPA) label requirements, the Occupational Safety and Health Administration (OSHA), and the PPQ Treatment Manual.

When treatments are conducted in a particular location on a regular basis, a permanent site should be designated. At such sites, the fan used to remove the fumigant from the enclosure during aeration must be connected to a permanent stack extending above the roof level.

Aeration of fumigated structures and ships are covered within those particular sections.

Responsibility for Aerating the Commodity

The label requires that at least two people trained in the use of the fumigant must be present at all times during gas introduction, treatment, and aeration. The PPQ officer, however, is not required to be continuously present at the fumigation site throughout the aeration process unless specified by the label or by State or local regulations.

If the fumigation is performed under a Section 18 Exemption, then a PPQ officer must be present at the initiation of aeration and to verify the final aeration readings.

TABLE 2-4-8: Determine Responsibility for Aerating the Commodity

If the Treatment Schedule is:	Then:
A FIFRA Section 18 Exemption	1. MONITOR the aeration of the enclosure, and 2. USE the table 2-4-9 to determine which aeration procedure to follow
A labeled Treatment Schedule	1. RELEASE the fumigation to the fumigator to aerate according to label instructions and the conditions of the compliance agreement. 2. RELEASE the commodity.

Materials Needed

The following materials will be needed to aerate the enclosure:

- ◆ SCBA⁶
- ◆ Colorimetric tubes (Draeger or Kitagawa for example)
- ◆ Exhaust fan⁷
- ◆ Exhaust duct⁸
- ◆ Danger signs⁹
- ◆ Materials for limiting access to area (barricades, rope)¹⁰
- ◆ PPQ Form 429

The following procedures apply to the aeration of all tarpaulin fumigations.

Securing the Area

Assuming that you have already restricted access and secured the fumigation area, you now must restrict access to the area where the exhaust duct extends on the ground beyond the enclosure.



During the first 10 minutes of aeration, it is recommended that no people should be within 200 feet of the exhaust duct outlet.

If this buffer zone is regulated by the State or municipality where the fumigation takes place, local regulations must be followed.

6 Materials required for both PPQ and commercial fumigator.
7 Materials to be furnished by the commercial fumigator.
8 Materials to be furnished by the commercial fumigator.
9 Materials to be furnished by the commercial fumigator.
10 Materials to be furnished by the commercial fumigator.

If it is impossible to restrict people from the area of aeration during regular work hours, consider aeration during another time of the day. When securing the duct outlet area, consider the direction of the wind. Face the duct outlet toward an open area, and away from people. Point the duct outlet upward to aid in dispersing the exhausted gas.

Advise the fumigator to use a physical barrier such as ropes, barricades, or walls to secure the area.

Placard the secure area near the exhaust outlet with the appropriate DANGER/PELIGRO signs. Make sure the placards meet the appropriate fumigant label or labeling requirements. The skull and crossbones should be present as well as “AREA UNDER FUMIGATION, DO NOT ENTER/NO ENTRE”; date of the fumigation; name of the fumigant used; and the name, address, and telephone number of the fumigator.

Unless you authorize their use, do *not* allow motorized vehicles to operate within the secure area.

Wearing Respiratory Protection

The fumigator and the PPQ officer monitoring the aeration must wear approved respiratory protection (SCBA, air supplied respirator, or a combination unit) when:

- ◆ Installing the exhaust system
- ◆ Opening the tarpaulin for aeration
- ◆ Removing the tarpaulin if measured levels of fumigant are above 5 ppm
- ◆ Any time during the aeration process when a risk of exposure to concentrations above 5 ppm exists. This includes any time the concentration is unknown.

TABLE 2-4-9: Determine the Aeration Procedure

If:	And:	And:	Then:
Nonsorptive	Containerized	—————→	GO to page-2-4-32
	Noncontainerized	Fresh fruits and vegetables, and cut flowers	GO to page-2-4-33
		Other than fresh fruits and vegetables, and cut flowers	GO to page-2-4-33
Sorptive, including yams and chestnuts	Containerized	—————→	GO to page-2-4-38
	Noncontainerized	—————→	GO to page-2-4-36

Aerating Nonsorptive, Containerized Cargo—Indoors and Outdoors

Step 1—Installing Exhaust System

Advise the fumigator to:

1. Install an exhaust fan (minimum of 5,200 cfm capacity) to a 16 inch, or greater, diameter duct located at the floor near rear doors of the container.
2. Install an air introduction duct system consisting of a 3,750 cfm, or greater, fan attached to a 12 inch, or larger, duct which reaches two-thirds of the length of the container at the top of the load. Have the ducts installed prior to the start of the fumigation. For indoor fumigation, extend the exhaust duct at least 30 feet beyond the building or through a vertical stack extending through the roof. For outdoor fumigations, extend the exhaust duct at least 30 feet beyond the container.



(1) Volume of enclosure (in cubic feet) divided by the sum of cubic feet per minute (cfm) of the exhaust fan(s) or exhaust blower equals the number of minutes required per complete gas volume exchange. (2) Sixty minutes divided by the number of minutes per gas volume exchange equals the number of complete gas exchanges per hour. The result should be in the range of 4 to 15. The faster the rate of aeration the better, particularly for perishable commodities. If the exhaust flow is connected to a methyl bromide recovery system, this device must not impede the flow rate to less than 4 volumes per hour.

Step 2—Aerating the Commodity

Advise the fumigator to:

1. Connect the exhaust duct to the exhaust fan.
2. Start the exhaust fan(s) and lift the end of the tarpaulin opposite the end at which the exhaust fan and duct are located.
3. Aerate for 3 hours.
4. Stop the aeration fans.
5. Use a colorimetric tube to take a concentration reading in the exhaust duct.

After the fumigator takes the concentration reading, you must record the date, concentration reading, and time in Block 39 of PPQ Form 429. Then use the following table to determine when to release the commodity.

TABLE 2-4-10: Determine When to Release the Commodity

If the gas concentration level is:	Then:
5 ppm or less	RELEASE the commodity
6 ppm or more	1. CONTINUE aeration until the concentration is 5 ppm or less ¹ , then 2. RELEASE the commodity

- ¹ Take concentration readings with colormetric tubes 4 feet from the base of the stack and 1 foot inside the stack at two locations between the cartons, but not inside the cartons.

Aerating Nonsorptive, Noncontainerized Cargo—Indoors and Outdoors

Step 1—Installing the Exhaust System



This step is optional for outdoor fumigations, but must be done for indoor fumigations.

Advise the fumigator to:

1. Install an exhaust duct (minimally one 3,500 cfm capacity fan connected to an exhaust duct). An exhaust duct is optional for outdoor fumigations.
2. Extend the exhaust duct outlet to an outside area where there is adequate ventilation and at least 30 feet away from the building or through a vertical exhaust stack extending through the roof.



(1) Volume of enclosure (in cubic feet) divided by the sum of cubic feet per minute (cfm) of the exhaust fan(s) or exhaust blower equals the number of minutes required per complete gas volume exchange. (2) Sixty minutes divided by the number of minutes per gas volume exchange equals the number of complete gas exchanges per hour. The result should be in the range of 4 to 15. The faster the rate of aeration the better, particularly for perishable commodities. If the exhaust flow is connected to a methyl bromide recovery system, this device must not impede the flow rate to less than 4 volumes per hour.

Step 2—Aerating the Commodity

Advise the fumigator to:

1. Start the exhaust fan.

Outdoor Fumigations

2. Lift the end of the tarpaulin opposite the end with the exhaust fan and duct (if used).
3. Aerate the enclosure for 2 hours.

Advise the fumigator to:

1. Stop the fans.
2. Remove the tarpaulin.
3. Take concentration readings with colormetric tubes 4 feet from the base of the stack and 1 foot inside the stack at two locations between the cartons, but not inside the cartons.

After the fumigator takes the concentration reading, you must then record the date, concentration reading, and time in Block 39 of PPQ Form 429. If you are not at the fumigation site, have the fumigator call and give you the information. Then use the following table to determine when to release the commodity.

TABLE 2-4-11: Determine When to Release the Commodity for Outdoor Fumigations

If the gas concentration level is:	Then:
5 ppm or less	RELEASE the commodity
6 ppm or more	1. CONTINUE aeration and take concentration readings until the level is 5 ppm or less, then 2. RELEASE the commodity

Indoor Fumigations

Advise the fumigator to:

1. Stop the fans.
2. Take concentration readings with colorimetric tubes in the exhaust duct.

After the fumigator takes the concentration reading, you must record the date, concentration reading, and time in Block 39 of PPQ Form 429. Then use the following table to determine when to release the commodity.

TABLE 2-4-12: Determine When to Release the Commodity for Indoor Fumigations

If the gas concentration level is:	Then:
5 ppm or less	1. ADVISE fumigator to REMOVE the tarpaulin, and 2. RELEASE the commodity
6 ppm to 99 ppm	1. ADVISE fumigator to REMOVE the tarpaulin, and 2. CONTINUE aeration until the concentration is 5 ppm or less, then 3. RELEASE the commodity
100 ppm or above	1. CONTINUE aeration and take concentration readings until the concentration level is below 100 ppm, then remove the tarpaulin, and 2. CONTINUE aeration until concentration is 5 ppm or less, then 3. RELEASE the commodity

Aeration Procedures for Fresh Fruits, Vegetables, and Cut Flowers—Indoors or Outdoors



Do **not** use these procedures for fresh chestnuts or yams. (See procedures for sorptive commodities on [page 2-4-38](#))

Step 1—Installing Exhaust System

Use the following table to determine which size fan to use.

TABLE 2-4-13: Determine Number of Fans

If the enclosure is:	Then:
Evenly stacked up to 25,000 ft ³	USE two 5,000 cfm fans connected to 3 foot diameter exhaust ducts
Irregularly stacked of any size	USE three 5,000 cfm fans connected to 3 foot diameter exhaust ducts
More than 25,000 ft ³	CONTACT Oxford Plant Protection Laboratory to get approval
Up to 1000 cu ft	USE one fan, 67-350 cfm
1001-15,000 cu ft	USE one or 2 fans. The volume of the enclosure divided by the sum of the cfm of the fans should equal a figure of 15 or less. Connect fan(s) to 3-ft diameter exhaust duct(s) 3 ft in diameter.
15,001-25,000 cu ft	USE two fans, each 1,000 to 5,000 cfm. The volume of the enclosure divided by the sum of the cfm of the fans should equal a figure of 15 or less. Connect fan(s) to exhaust duct(s) 3 ft in diameter.
More than 25,000 cu ft	CONTACT Oxford Plant Protection Laboratory for advice prior to conducting the first fumigation.

An alternate procedure to using exhaust fans and ducts is to aerate through a vertical stack.



(1) Volume of enclosure (in cubic feet) divided by the sum of cubic feet per minute (cfm) of the exhaust fan(s) or exhaust blower equals the number of minutes required per complete gas volume exchange. (2) Sixty minutes divided by the number of minutes per gas volume exchange equals the number of complete gas exchanges per hour. The result should be in the range of 4 to 15. The faster the rate of aeration the better, particularly for perishable commodities. If the exhaust flow is connected to a methyl bromide recovery system, this device must not impede the flow rate to less than 4 volumes per hour.

Step 2—Aerating the Commodity

Advise the fumigator to:

1. Connect the exhaust duct to the exhaust fan.

2. Start the exhaust fan(s) and lift the end of the tarpaulin opposite the end at which the exhaust fan and duct are located.
3. Aerate for 2 hours.
4. Remove the tarpaulin and allow 2 hours for passive aeration.
5. Take a final reading.

After the fumigator takes the concentration reading, you must record the date, concentration reading, and time in Block 39 of PPQ Form 429. Then use the following table to determine when to release the commodity.

TABLE 2-4-14: Determine When to Release the Commodity

If the gas concentration level is:	Then:
5 ppm or less	RELEASE the commodity
6 ppm or more	1. CONTINUE aeration and take concentration readings until the level is 5ppm or less, then 2. RELEASE the commodity



Give the original and one copy to your supervisor for review. The supervisor should keep the original for port files and send one copy to:

USDA, APHIS, PPQ
Oxford Plant Protection Laboratory
901 Hillsboro Street
Oxford, NC 27565

Aerating Sorptive, Noncontainerized Cargo—Indoors and Outdoors

Step 1—Installing the Exhaust System



This step is optional for outdoor fumigations, but must be done for indoor fumigations.

Advise the fumigator to:

1. Install an exhaust duct (minimally one 3,500 cfm capacity fan connected to an exhaust duct).
2. Extend the exhaust duct outlet to an outside area where there is adequate ventilation and at least 30 feet away from the building or through a vertical exhaust stack extending through the roof.

Outdoor Fumigations

Step 2—Aerating the Commodity

Advise the fumigator to:

1. Lift both ends of the tarpaulin.
2. Start the circulation fans and exhaust fans (if available).
3. Run the fans for 4 hours.
4. Remove the tarpaulin.
5. Take concentration readings with colormetric tubes 4 feet from the base of the stack and 1 foot inside the stack at two locations between the cartons, but not inside the cartons.

After the fumigator takes the concentration reading, you must record the date, concentration reading, and time in Block 39 of PPQ Form 429. Then use the following table to determine when to release the commodity.

TABLE 2-4-15: Determine when to Realease the Commodity

If the gas concentration level is:	Then:
5 ppm or less	RELEASE the commodity
6 ppm or more	1. CONTINUE aeration and take concentration readings until the level is 5ppm or less, then 2. RELEASE the commodity

Indoor Fumigations

Advise the fumigator to:

1. Complete the installation of the exhaust duct.
2. Start the circulation fans and exhaust fans.
3. Lift the end of the tarpaulin opposite the exhaust fan.
4. Run the fans for 4 hours.
5. Stop the fans and take concentration readings with colorimetric tubes in the exhaust duct within 2 feet of the enclosure.
6. Remove the tarpaulin.

After the fumigator takes the concentration reading, you must then record the date, concentration reading, and time in Block 39 of PPQ Form 429. Then use the following table to determine when to release the commodity. Take successive readings at intervals of not less than 2 hours. Take concentration readings with colormetric tubes 4 feet

from the base of the stack and 1 foot inside the stack at two locations between the cartons, but not inside the cartons. You, as well as the fumigator, may take concentration readings.

TABLE 2-4-16: Determine When to Release the Commodity for Indoor Fumigations

If the gas concentration level is:	Then:
5 ppm or less	1. REMOVE the tarpaulin, and 2. RELEASE the commodity
6 ppm to 99 ppm	1. REMOVE the tarpaulin, and 2. CONTINUE aeration until the concentration is 5 ppm or less ¹ , then 3. RELEASE the commodity
100 ppm or above	1. CONTINUE aeration and take concentration readings until the concentration level is below 100 ppm, then remove the tarpaulin, and 2. CONTINUE aeration until concentration is 5 ppm or less, then 3. RELEASE the commodity

1 Take concentration readings with colormetric tubes 4 feet from the base of the stack and 1 foot inside the stack at two locations between the cartons, but not inside the cartons.

Aerating Sorptive Commodities in Containers—Indoors and Outdoors

Step 1—Installing the Exhaust System



This step is not required for outdoor fumigations.

Advise the fumigator to:

1. Install an exhaust fan (minimum of 5,200 cfm capacity) to a 16 inch or greater diameter duct located at the floor near rear doors or the container.
2. Install an air introduction duct system consisting of a 3,750 cfm or greater fan attached to a 12 inch or greater duct which reaches two-thirds of the length of the container at the top of the load. Have the ducts installed prior to the start of the fumigation. For indoor fumigations, extend the exhaust duct at least 30 feet beyond the building or through a vertical stack extending through the roof. For outdoor fumigations, extend the exhaust duct 30 feet beyond the container.

Step 2—Aerating the Commodity

Indoors

Advise the fumigator to:

1. Complete installation of exhaust duct and begin exhaust fan operation.
2. Lift both ends of the tarpaulin and begin exhaust fan operation. Do not remove the tarpaulin until the gas concentration level is below 100 ppm (see [Table 2-4-17](#)).
3. Start the circulation and air introduction fans. Sorptive commodities generally require 12 hours or longer to aerate. Since sorptive commodities vary in their rates of desorption, aeration may be completed in less than 12 hours. Require a minimum of 4 hours aeration for all sorptive commodities.
4. Take concentration readings with colorimetric tubes in the exhaust duct 2 feet within the enclosure. Record your readings on PPQ Form 429. Take successive readings within the enclosure 4 feet from the floor, at two representative locations. Take the readings between the cartons, but not inside the cartons.

After the fumigator takes the concentration reading, you must record the date, concentration reading, and time in Block 39 of PPQ Form 429. Then use [Table 2-4-17](#) to determine when to release the commodity.

TABLE 2-4-17: Determine when to Release the Commodity

If the gas concentration level is:	Then:
5 ppm or less	1. ADVISE fumigator to REMOVE the tarpaulin, and 2. RELEASE the commodity
6 ppm to 99 ppm	1. HAVE fumigator REMOVE the tarpaulin, and 2. CONTINUE aeration until the concentration is 5 ppm or less, then 3. RELEASE the commodity
100 ppm or above	1. CONTINUE aeration and take concentration readings until the concentration level is below 100 ppm, then remove the tarpaulin, and 2. CONTINUE aeration until concentration is 5 ppm or less, then 3. RELEASE the commodity

Outdoors

Advise the fumigator to:

1. Complete installation of exhaust duct and begin exhaust fan.
2. Lift both ends of the tarpaulin that are furthest from exhaust fan.
3. Start the circulation and air introduction fans. Sorptive commodities generally require 12 hours or longer to aerate. Since sorptive commodities vary in their rates of desorption, aeration may be completed in less than 12 hours. Require a minimum of 4 hours aeration for all sorptive commodities.
4. Remove the tarpaulin after 4 hours aeration.

5. Stop the circulation fans and take concentration readings with colorimetric tubes 4 feet from the ground and 1 foot inside the outer edge of the stack between the cartons but not inside the cartons. One location is sufficient.

After the fumigator takes the concentration reading, you must record the date, concentration reading, and time in Block 39 of PPQ Form 429. If you are not at the fumigation site, have the fumigator call and give you the information. Then use **Table 2-4-18** to determine when to release the commodity.

TABLE 2-4-18: Determine when to Release the Commodity

If the gas concentration level is:	Then:
5 ppm or less	RELEASE the commodity
6 ppm or more	1. CONTINUE aeration and take concentration readings until the level is 5ppm or less, then 2. RELEASE the commodity